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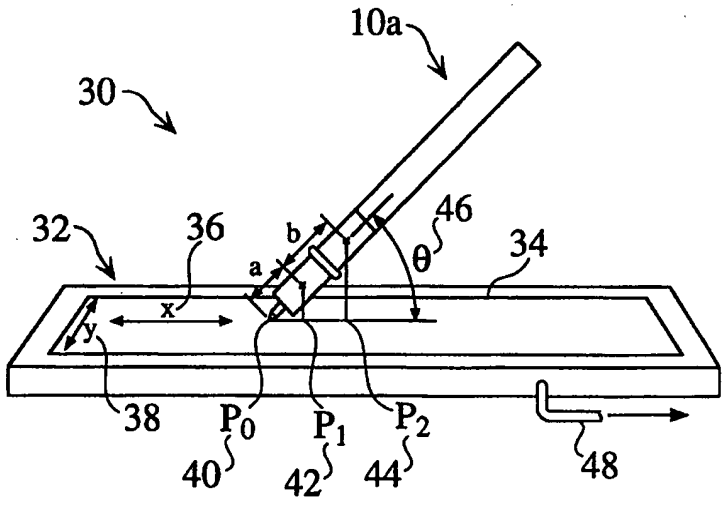
(54) Title: IMPROVED PEN POSITIONING SYSTEM



(57) Abstract

A pen positioning system is provided, in which a pen, having multiple output elements, is adapted to accurately determine the location of the pointing tip of the pen, in relation to an electronic tablet. The output elements, preferably ultrasonic transmitters having distinct frequencies, are located at a fixed distance from each other, and are also related in space to the pointing tip of the pen. The geometric relationship between the output elements and the pointing tip of the pen allows the location of the pointing tip to be determined, independent of the angle at which the pen is inclined against the surface of the writing tablet. A detection system is used to receive the output signals from the output elements, isolate the output signals from each other, and process them independently to determine the location of the output elements and of the pointing tip of the pen. Alternative embodiments include an additional output element on a pressure sensitive shell of the pen, which allows the pen to accurately provide pressure sensitive output signal information.

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IMPROVED PEN POSITIONING SYSTEM

FIELD OF THE INVENTION

The invention relates to the field of electronic input systems. More particularly, the invention relates to a system for determining the position of an electronic pointing device.

BACKGROUND OF THE INVENTION

Digitizing pen and tablet systems are used for a variety of electronic applications. These systems typically include a tablet, a position indicating pen, and associated electronics for determining the interaction between the tablet and the position indicating pen. A digital data signal is typically derived to represent the relative position of the position indicating pen and the tablet.

The calculated location of current prior art pens, in relation to an electronic tablet, have a systematic user error of approximately ±10 pixels. This error is determined solely by the angle at which the pen is inclined towards the tablet, and the distance from the tip of the pen to the center of a transmitting element.

M. Phillips, T. Philbin, and B. Blesser, *Coordinate Determining Device Using Spatial Filters*, U.S. Patent No. 4,963,703 (16 October 1990) disclose a digitizing tablet, in which "two sets of circuitous conductive lines form grids each connected at one end to a surrounding conductive loop. All outputs are measured from the conductive loop as a multiplexor sequentially grounds the grids one at a time. The outputs are fed through linear spatial filters which are used to produce intermediate signals which are in turn combined to arrive at raw position signals for a position indicating coil located over the work surface. Separate sets of linear spatial filters may be used to produce two raw position signals differently responsive to tilt which can then be combined to arrive at a true position insensitive to tilt". Phillips et al. also disclose a stylus having a single conductive coil, which is used as a position indicating implement over a work surface.

The disclosed prior art systems and methodologies thus provide basic pen and tablet positioning systems for determining the spatial relationship between a pen and a tablet, but fail to provide an accurate means for determining the position of the tip of the pen, independent of the angular displacement of the pen in relation to the tablet. J. Romein, *Acoustic Writing Combination Comprising a Stylus With An Associated Writing Tablet*, U.S. Patent No. 4,246,439 (January 20, 1981) discloses an acoustic

writing stylus provided with two ultrasonic sound sources that are situated at different distances from a stylus tip and that are operated to alternately produce ultrasonic signals, thereby providing a scheme for more accurately determining the position of the stylus tip. However, because this system requires that alternate ultrasonic bursts at the same frequency produced by each of the ultrasonic sound sources be received to measure the respective distances of each of the sound sources from a receiver (microphone) there is a likelihood that angular movement of the stylus between bursts can alter the measured distance and produce an inaccurate determination of stylus tip position. The development of a more accurate, improved pen positioning system would constitute a major technological advance.

SUMMARY OF THE INVENTION

An improved pen positioning system is provided, in which a pen, having multiple output elements, is adapted to determine the location of the pointing tip of the pen accurately, in relation to an electronic tablet. The output elements, preferably ultrasonic transmitters having distinct frequencies, are located a fixed distance from each other, and are also related in space to the pointing tip of the pen. The geometric relationship between the output elements and the pointing tip of the pen allows the location of the pointing tip to be determined, independent of the angle which the pen is inclined against the surface of the writing tablet. A detection system is used to receive the output signals from the output elements, isolate the output signals from each other, and process them independently to determine the location of the output elements and of the pointing tip of the pen.

Alternative embodiments include an additional output element on a pressure sensitive shell of the pen, which allows the pen to accurately provide pressure sensitive output signal information.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a side view of a dual output element pen;

Figure 2 is a detailed side view of a dual output element pen, which shows spacing between the pen tip and the center of each output element;

Figure 3 is a perspective view of a dual output element pen at an inclined angle in relation to an electronic tablet;

Figure 4 shows the relative geometry between an inclined dual output element pen and an electronic tablet;

Figure 5 illustrates the geometric relationship between an inclined dual output element pen and an electronic tablet;

Figure 6 shows the projected x and y coordinates of a pen tip and dual output elements for an inclined dual output element pen onto an electronic tablet;

Figure 7 is a flow chart which illustrates how the signal from a dual output element pen relative to an electronic tablet is processed;

Figure 8 is a partial side view of an alternate embodiment of a dual output element pen; and

Figure 9 is a partial side view of a dual output element pen having an integrated pressure sensitive signal.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 1 is a side view of a dual output element pen 10a. The pointing end 14 of the pen 10 has a pointing tip 16, with which a user points to or draws upon the surface 34 (FIG. 3) of an electronic tablet 32 (FIG. 3). A first output element 18 is located on the pen 10, and has a first point source 20 for a first output signal. A second output element 22 is located on the pen 10, and has a second point source 24 for a second output signal. Figure 2 is a detailed side view of the dual output element pen 10a, which shows the spacing between the pen tip 16 and the point sources 20,24 of each output element 18, 22. The first distance 26 is denoted as "a" between the pointing tip 16 and the first point source 20 of the first output element 18. The second distance 28 is denoted as "b" between the pointing tip 16 and the second point source 24 of the second output element 22.

The first output element 18 and the second output element 22 of the positioning pen 10a are preferably ultrasonic transmitters. The first and second output elements 18,22 transmit signals of distinct frequencies, which allows the location of the pen tip 16 to be determined accurately, as described below. The detection system isolates the output signals, and processes them independently.

Figure 3 is a perspective view of the positioning pen system 30, in which a dual output element pen 10a is shown at an inclined angle 46 in relation to an electronic tablet 32, indicated as q. The electronic tablet 32 has a planar work surface 34, which includes an X coordinate axis 36, and a Y coordinate axis 38. Signals from the electronic tablet 32 are output through cable 48 for external processing. Figure 4 shows the relative geometry between an inclined dual output element pen 10 a and an electronic tablet 32. Point P_0 (40) corresponds to the location of the pointing tip 16 of the pen 10a on the tablet 32. Point P_1 (42) corresponds to the projected location of the first point

source 20 of the first output element 18 of the pen 10a onto the tablet 32. Point P_2 (44) corresponds to the projected location of the second point source 24 of the second output element 22 of the pen 10a onto the tablet 32. Figure 5 illustrates the geometric relationship between the inclined dual output element pen 10a and the electronic tablet 32, for any angle q between the pen 10a and the tablet 32.

For any angle q between the pen 10 and the tablet 32,

$$\{a/(P_0-P_1)\} = \{b/(P_1-P_2)\}. \quad (1)$$

Therefore,

$$\{(a/b)*((P_1-P_2)\} = (P_0-P_1), \text{ or} \quad (2)$$

$$P_o = P_1 + \{(a/b)*(P_1-P_2)\}. \quad (3)$$

The maximum error in the measurements of P_1 and P_2 is approximately ± 2 pixels. The total system error is approximately ± 4 pixels.

Figure 6 shows the projected x and y coordinates of the pen tip 16, first output element 18, and second output element 22 for an inclined pen 10 onto an electronic tablet 32. The system produces the projected coordinates X_1 and Y_1 of the first point source 20 of the first output element 18. The system also produces the projected coordinates X_2 and Y_2 of the second point source 24 of the second output element 22. Using these two points 43 and 45 , and the known measurement of the positioning pen 10, the location (X,Y) 41 of the pen tip 16 is determined mathematically.

The location of X is given by:

$$X = X_1 + (a/b) * (X_1 - X_2), \quad (4)$$

and the location of Y is given by:

$$Y = Y_1 + (a/b) * (Y_1 - Y_2). \quad (5)$$

Multiple Output Signal Detection Process. Figure 7 is a flow chart 50 which illustrates how the signal from a dual output element pen 10 relative to an electronic tablet 32 is processed. The multiple output signal detection process to

determine the location of the tip 16 of the positioning pen 10 comprises the following steps:

i) inputting a plurality of pen signals to an ultrasound detector 52;

ii) amplifying the input signals 54, if necessary;

ii) feeding the amplified signals through a plurality of filters (56,58) to produce the X and Y components of each output element 18,22;

iv) feeding the X and Y components of each output element 18,22 to a microcontroller 60; and

v) determining the location of the pen tip 16 mathematically 60.

System Advantages. The pen positioning system 30 provides many advantages over prior pen positioning systems. As the pen 10 is located at an angle q, in relation to an input tablet 32, the angular displacement of the pen 10 can be compensated for. The use of two transmitting elements 18, 22 provides a vector between the two points representing the two transmitting elements, which are then used to accurately locate the tip 16 of the pen 10 in relation to the tablet 32.

The dual output element pen 10 produces two points in space, related to each other, and each related to the tip 16 of the pen 10. By having a first reference point 20 of a first output element 18, and a second reference point 24 of a second output element 22, in which there is a fixed spatial relationship between the first reference point 20 and the second reference point 24, the location of the pen tip 16 can be accurately determined.

Alternate Embodiments. Figure 8 is a partial side view of an alternate embodiment of a dual output element pen 10b, in which a first output element 18b and a second output element are located a distance from each other.

Figure 9 is a partial side view of a dual output element pen 10c having an integrated pressure sensitive signal. An outer shell 62, having an output element 64, is slidably mounted about the body of the pressure sensitive pen 10c, and is biased by a spring 66. The location of the pointing tip 16c is accurately located in respect to an electronic tablet, as described above. Applied pressure from a user acts to displace the shell reference point 68 of the shell output element 64, in relation to the body of the pen 10c. The relative distance between the shell reference point 68 and the body of the pen

10c can be used to communicate pressure to external systems. This pressure signal can be used for many applications, such as painting or drawing applications, in which the applied pressure communicates the width of an electronic paint stroke in a digital painting software program.

Although the pen positioning system and its methods of use are described herein in connection with computer input systems, the techniques can be implemented for other control or display devices, or any combination thereof, as desired.

Accordingly, although the invention has been described in detail with reference to a particular preferred embodiment, persons possessing ordinary skill in the art to which this invention pertains will appreciate that various modifications and enhancements may be made without departing from the spirit and scope of the claims that follow.

CLAIMS

What is claimed is:

1. A positioning pen, comprising:

a pen tip;

a first output element adapted to transmit a first signal having a first frequency, said first transmitter located a first distance away from said pen tip; and

a second output element adapted to transmit a second signal having a second frequency, said second frequency different from said first frequency, said second transmitter located a second distance away from said pen tip, said second distance different than said first distance.

2. The positioning pen of Claim 1, wherein said first output element is an ultrasonic transmitter.

3. The positioning pen of Claim 1, wherein said second output element is an ultrasonic transmitter.

4. The positioning pen of Claim 1, further comprising:

an outer shell slidably biased in relation to said pen tip, said first output element, and said second output element; and

a third output element attached to said outer shell, said third output element adapted to transmit a third signal having a third frequency, said third frequency different from said first frequency and said second frequency.

5. The positioning pen of Claim 4, wherein said third output element is an ultrasonic transmitter.

6. A pen positioning system, comprising:

a pen having a pen tip, a first output element located a first distance away from said pen tip, said first output element adapted to transmit a first signal having a first frequency, and a second output element located a second distance away from said pen tip, said second distance different than said first distance, said second output element adapted to transmit a second signal having a second frequency different from said first frequency;

a detector for receiving said first signal and said second signal;

means for isolating said first signal and said second signal; and

means for receiving said isolated first signal and said second signal, for determining the location of said first output element, for determining the location of said first output element, and for determining the location of said pen tip.

7. The positioning pen system of Claim 6, wherein said first output element is an ultrasonic transmitter.

8. The positioning pen system of Claim 6, wherein said second output element is an ultrasonic transmitter.

9. The positioning pen system of Claim 6, further comprising:

an outer shell slidably biased in relation to said pen tip, said first output element, and said second output element;

a third output element attached to said outer shell, said third output element adapted to transmit a third signal having a third frequency, said third frequency different from said first frequency and said second frequency;

wherein said detector is adapted for receiving said third signal;

wherein said means for isolating said first signal and said second signal is adapted for isolating said third signal from said first signal and said second signal; and

means for receiving said isolated third signal and for determining the location of said third output element in relation to said location of said first output element and said second output element.

10. The positioning pen of Claim 9, wherein said third output element is an ultrasonic transmitter.

11. The positioning pen of Claim 6, wherein said pen tip position (P_0) is determined in accordance with the formula

$$P_0 = P_1 + \{(a/b) * (P_1 - P_2)\}$$

where P_1 is the projected location of the first signal; P_2 is the projected location of the second signal; or is the distance between the pen tip and said first output element point source; and b is the distance between said first output element point source and said second output element point source.

12. A process, comprising the steps of:

providing a pen having a pen tip, a first output element located a first distance away from said pen tip, said first output element adapted to transmit a first signal having a first frequency, and a second output element located a second distance away from said pen tip, said second distance different than said first distance, said second output element adapted to transmit a second signal having a second frequency different from said first frequency;

detecting said first signal and said second signal;

isolating said first signal and said second signal; and

determining the locations of said first output element, said first output element, and said pen tip.

13. The process of Claim 12, further comprising the step of:

amplifying said first signal and said second signal.

14. The process of Claim 12, wherein said first output element is an ultrasonic transmitter.

15. The process of Claim 12, wherein said second output element is an ultrasonic transmitter.

16. The process of Claim 12, further comprising:

providing an outer shell slidably biased in relation to said pen tip, said first output element, and said second output element;

providing a third output element attached to said outer shell, said third output element adapted to transmit a third signal having a third frequency, said third frequency different from said first frequency and said second frequency;

detecting said third signal;

isolating said third signal from said first signal and from said second signal; and

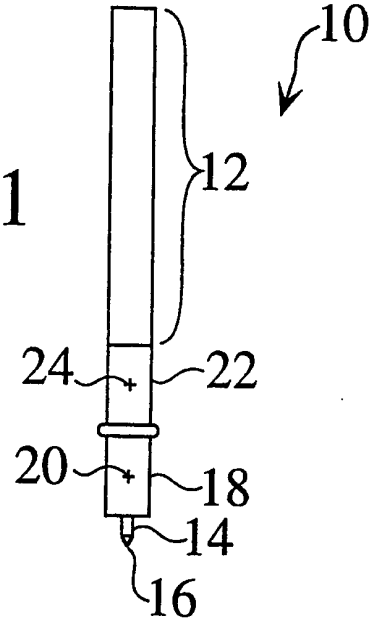
determining the location of said third output element in relation to said location of said first output element and said second output element.

17. The process of Claim 16, wherein said third output element is an ultrasonic transmitter.

18. The process of Claim 16, further comprising the step of:

amplifying said third signal.

Fig. 1



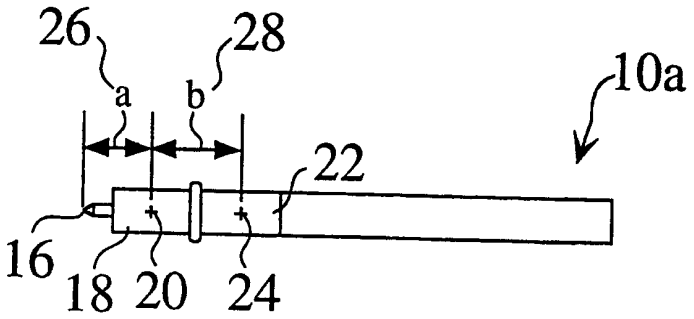


Fig. 2

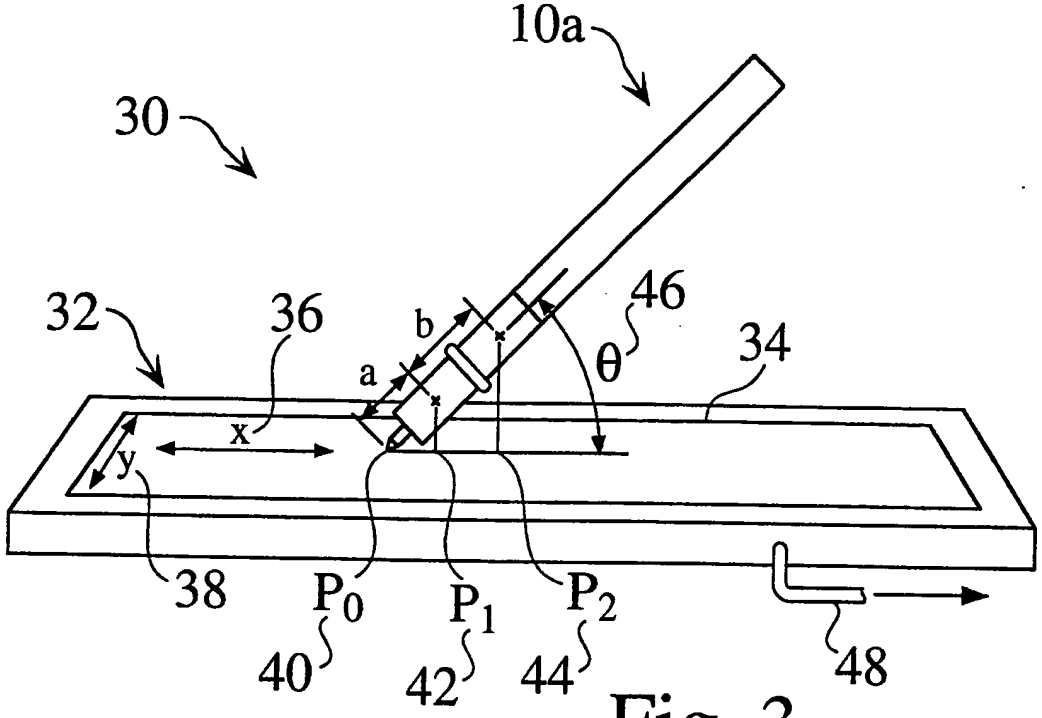

10a
30
32
36
b
a
46
θ
34
x
y
38
P0
P1
P2
40
42
44
48

Fig. 3

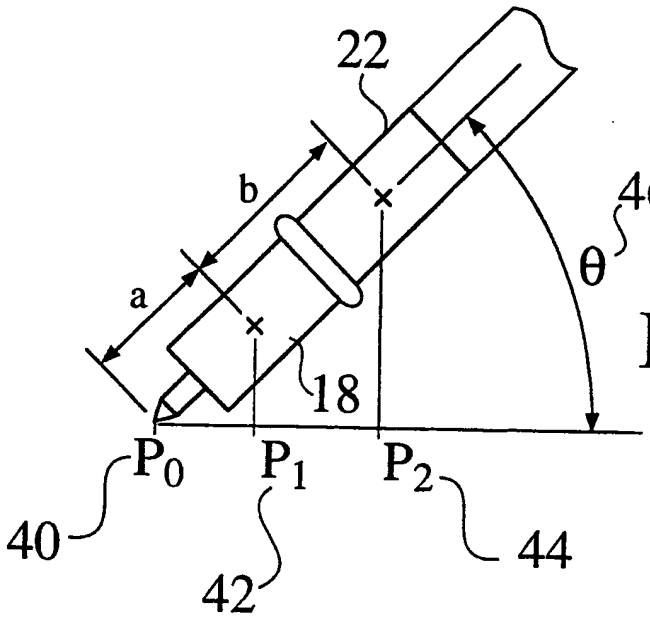

22
b
46
θ
a
18
P0
P1
P2
40
42
44

Fig. 4

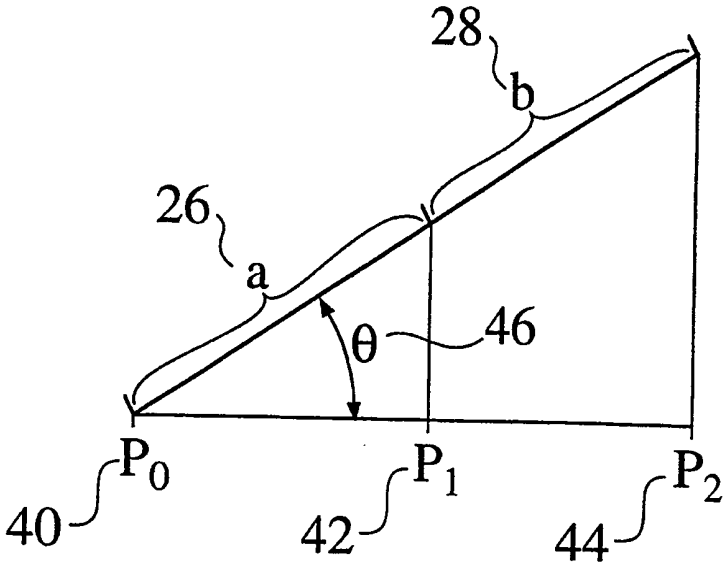


Fig. 5

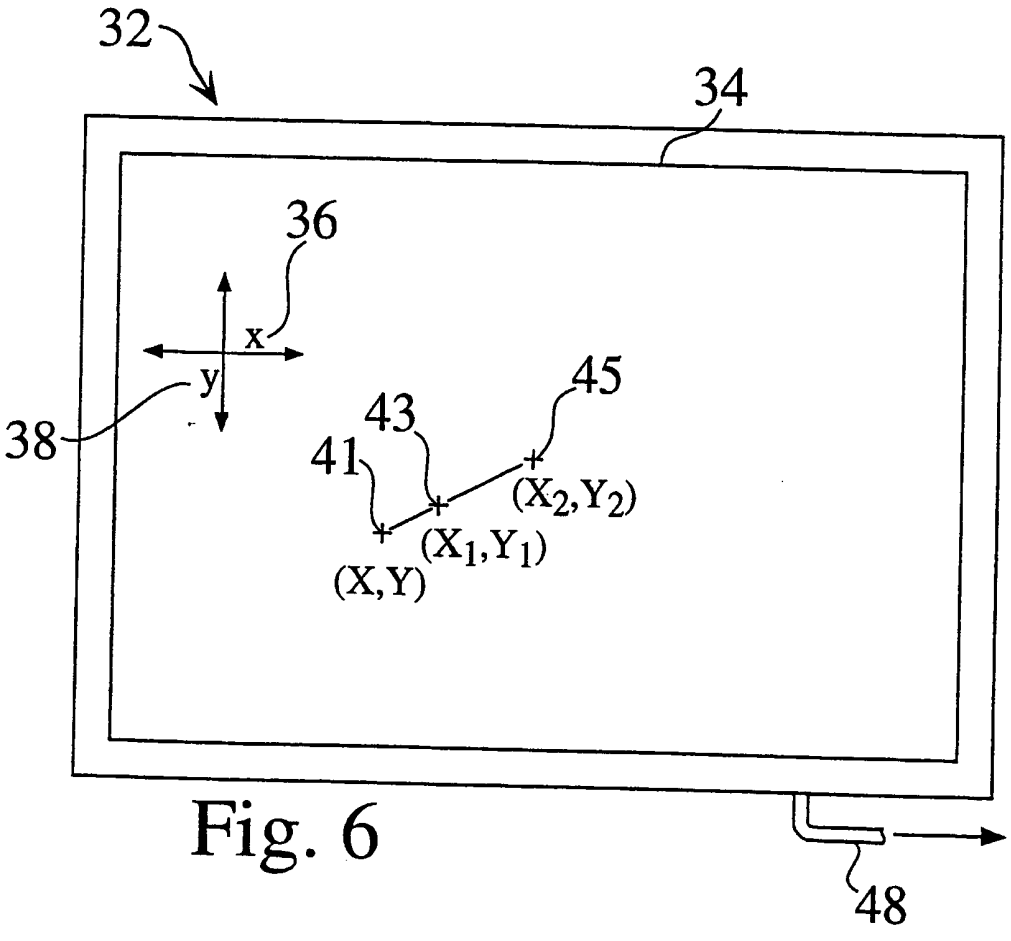


Fig. 6

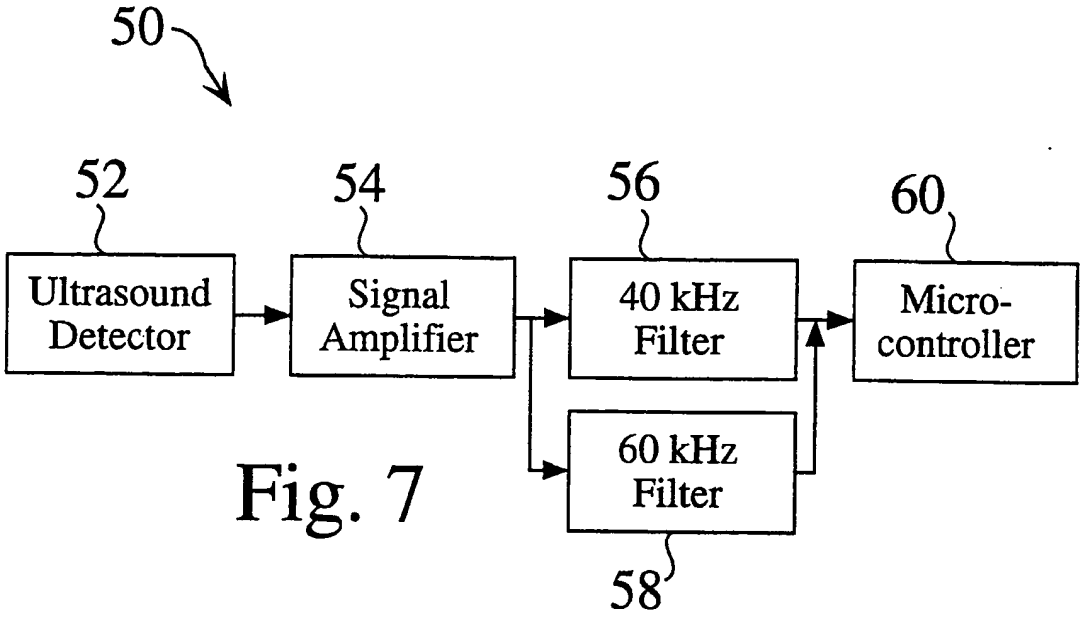


Fig. 7

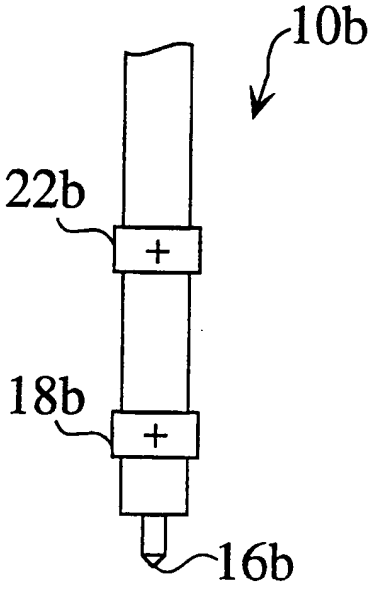


Fig. 8

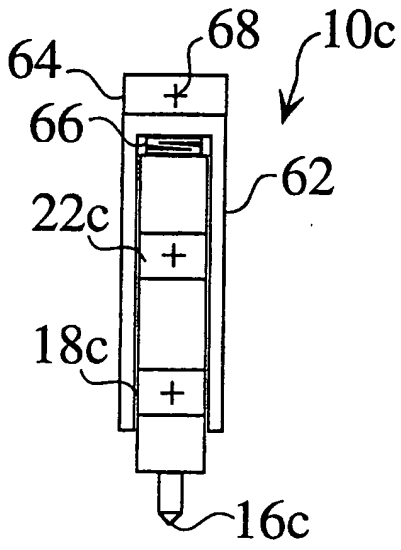


Fig. 9

INTERNATIONAL SEARCH REPORT

In tional Application No
PCT/US 98/25727

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G06K11/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 94 11844 A (DEBUISSER THOMAS ;GILLIARD LAURENT (FR); LECTRA SYSTEMES SA (FR);) 26 May 1994 see page 6, line 3 - page 7, line 2 see page 10, line 21 - page 11, line 35 see page 15, line 1 - line 3 see page 17, line 18 - line 24	1-18
X	US 4 577 057 A (BLESSER BARRY) 18 March 1986 see column 3, line 31 - line 57 see column 5, line 38 - column 6, line 21 see column 6, line 54 - line 57; figure 5	1-3,6-8, 12-15
A	US 4 246 439 A (ROMEIN JACOB J) 20 January 1981 see the whole document	1-3,6-8, 12-15

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[X] Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search	Date of mailing of the international search report
31 March 1999	08/04/1999

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/25727

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 772 149 A (SEIKO INSTR INFORMATION DEVICE) 7 May 1997 see figures 1-14	9,16

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

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Information on patent family members

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